CryoKinetic Cleaning on Cu/Low-k Dual Damascene Structures

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INTRODUCTION

When cleaning wafers that use Cu dual damascene interconnects, a whole host of problems can be encountered. These include the standard Back End of Line (BEOL) cleaning problems of low cleaning efficiency and excessive etch rates leading to shifts in critical dimensions and metal corrosion. In addition, one must deal with shifts in dielectric constant, compatibility with Cu, corner rounding, collapsing trench walls, film delamination, and lets not forget Photo diode Induced Copper Redeposition (PICR). One clean that avoids all these pitfalls, is the Ar/N_2 cryogenic aerosol (CryoKinetic) clean. In those instances where particle cleaning is the main issue, wet chemistries and their inherent issues with Cu and low-k dielectrics, can be avoided by using CryoKinetic cleaning. Cleaning efficiency has been demonstrated on polished surfaces and surfaces with open vias. The process has also been shown to have no effect on low-k films through FTIR spectra and dielectric constant measurements while maintaining film integrity. In previous studies Ar/N_2 cryogenic cleaning has been shown to be non-damaging and non-charging to the wafer surface [1]. Defect removal and yield improvement using this process for Al/TEOS BEOL has also been previously reported [2].

CLEANING EFFICIENCY

CryoKinetic cleaning is effective at removing many defects that are generated during BEOL processing sequences. Figure 1 shows typical defects on the surface of the interlevel dielectric (ILD) following copper damscene polishing and cleaning. These defects are easily removed with the CryoKinetic process. Removal of these and many other types of defects significantly improves electrical yields in the Cu/Low-k dual damascene integrated process. Figure 2 compares cleaning efficiency and particle additions for various pre-ILD cleans. CryoKinetic cleaning matches the removal efficiency of the best wet clean with fewer particle additions while avoiding PICR, changes to critical dimensions, and changes to the dielectric constant.

NO EFFECT ON LOW-K MATERIALS

Analysis of low-k materials before and after CryoKinetic cleaning demonstrates that the process has no deletrious effects on the properties of those films. Characterization has been carried out by spectroscopic ellipsometry and FTIR as well as by determination of dielectric constants on patterned, metallized wafers. Figure 3 shows that the cryokinetic process has no significant effect on the chemical structure of common low-k films.

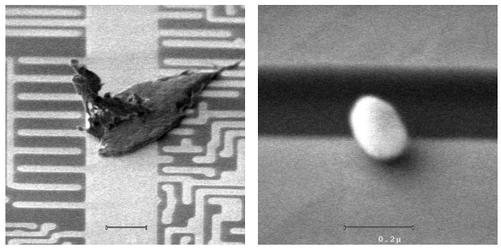

Figure 1. Typical defects that are removed by Ar/N_2 cryogenic aerosol cleaning. The defect on the left is approximately 10 microns wide while the defect on the right is approximately 0.2 microns wide.

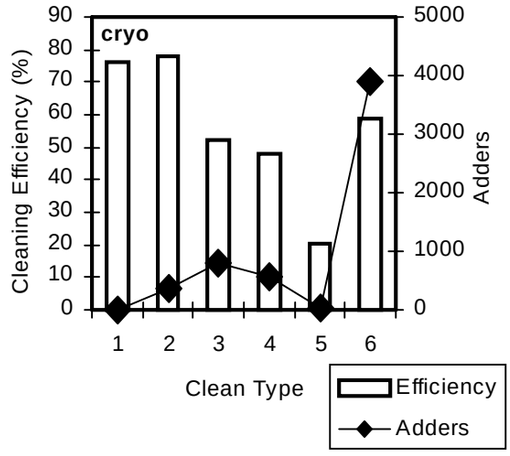

Figure 2. Cleaning effiency for pre-ILD deposition comparing CryoKinetic cleaning (clean 1) to various wet cleans.

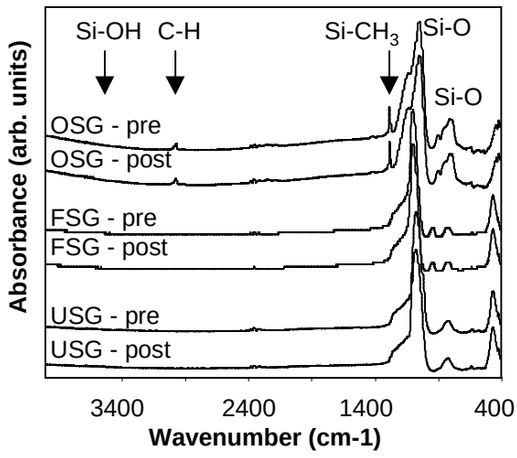

Figure 3. FTIR Characterization of a various films before and after Ar/N_2 cryogenic aerosol processing. No significant changes in peak heights are detected

[1] Weygand, J. F. et al., *Micro*, 15(4):47, 1997.

[2] Butterbaugh, J.W. et al. *Micro*, 17(6):33, 1999.